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21st Century C4ISR/IW Technology Insertion and Management

ABSTRACT

This paper addresses the influences and process that Space and Naval Warfare (SPAWAR) Systems Command uses to introduce the latest Command, Control, Communications, Computers, Intelligence, Sensors, Reconnaissance and Information Warfare (C4ISR/IW) technologies to Naval Shipbuilding. This technology insertion affects both individual ships C4ISR/IW capability and that of the entire Battle Group / Amphibious Readiness Group (BG/ARG).

INTRODUCTION

The combat capability of any given BG/ARG is largely dependent upon its ability to function as a team. The ability to communicate, navigate as a unit or as a member of the BG/ARG, requires common, interoperable C4ISR/IW systems. In order to ensure that there is compatibility throughout the BG/ARG, there must exist a common industrial approach to fielding technology that meets the established C4ISR/IW baselines.

Rapidly changing information and computer system technologies provide a challenging opportunity for both commercial businesses and government. The managers of today are faced with a myriad of programmatic issues such as how to cost-effectively procure, build, integrate, test, install, operate and maintain systems under the conditions of constrained budgets, rapidly advancing technology, and emerging and unforeseen mission requirements. Managers face the additional challenge in ensuring that *"State of the Market"* C4ISR/IW systems are fielded within the contractually stipulated shipbuilding process

In order to meet the challenge, SPAWAR systematically uses a two-pronged approach. First, SPAWAR takes advantage of the opportunities offered by the implementation of the 1994 Federal Acquisition Streamline Act and 1996 National Defense Authorization Act. These two changes to the acquisition process were the core of acquisition reform. Second, SPAWAR employs system engineering and program management best practices such as Turnkey and Horizontal Integration processes. These processes ensure the latest C4ISR/IW technology is installed in New Construction ships while making certain that the C4ISR/IW requirements of their assigned BG/ARG are met and that <u>all</u> members of the BG/ARG are fully C4ISR/IW interoperable.

ACQUISITION REFORM

Acquisition Reform allows the Department of the Navy the ability to leverage from "best commercial practices" and technology evolution to keep pace with state-of-the-art developments. The elimination of many Military Specifications and Standards (MILSPECs and MILSTDs) reduces overall costs and increases system flexibility allowing the government to take advantage of timely technology breakthroughs by streamlining procurement procedures.

In addition, the Acquisition Reform open systems approach allows commercially available, widely accepted standard products from multiple vendors to be brought into the military environment that are applicable to both software and hardware. In general, under the old acquisition system the common use of military specifications and standards in producing systems locked the government into suppliers that had little incentive to reduce cost or improve the product.

With the advent of Commercial-Off-The-Shelf (COTS), Government-Off-The-Shelf (GOTS), and Non-development Item (NDI) products, programs require a new process for managing the changes. In the MILSPEC world, the Government controlled if, when, and how changes would be done. In the COTS world, the Government can neither dictate to industry when technology changes will occur nor

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direct a vendor to change a product line. The use of COTS, GOTS, and NDI hardware presents challenges to the traditional configuration management practices and support structure. For example, computers being installed on platforms are continuously being replaced by newer technology models that must be tested each time to ensure they work with existing software while meeting requisite environmental requirements of the individual platforms. In addition, the government is relying more on commercial manuals for guidance on troubleshooting and operating procedures.

On the other hand, the use of COTS, GOTS, and NDI hardware and software is innovative and creative because incremental upgrades can be integrated, tested and fielded in a shorter time than traditional developmental efforts. The use of GOTS and COTS hardware common with other systems also allows more economical procurement of hardware and spares. For instance, common data processing cards, monitors, raid and hard drives equates to bulk buys and common parts sparing.

RISK IN HIGH TURNOVER TECHNOLOGY

Since C4ISR/IW system technology refreshes on an average every 18 months, the high turnover will add risk to fielding *"state-of-the-market"* technology in the shipbuilding process. The notional ship construction timeline can take up to nine years, depending upon the ship class. The lengthy shipbuilding process coupled with technology refresh rates and the requirement to provide detailed design data or Government Furnished Information (GFI) for C4ISR/IW systems to shipbuilders, as early as six months after contract award, results in C4ISR/IW systems being out of date at install. In some cases, the technology fielded on new ships was over five years old before the ship was commissioned. In order for the newly constructed ships to be interoperable and compatible with its assigned BG/ARG, extensive, and costly, ship alterations and upgrades were made. To avoid these costly changes, a Turnkey engineering approach has been implemented.

Turnkey

Turnkey as defined by Webster's is; *ready for occupancy when turned over to the owner.* Over the years, SPAWAR, Naval Sea Systems Command (NAVSEA) and industry teams have been very successful in working together to define and implement collaborative engineering, design, and distributed testing processes. Turnkey is one of the latest processes that enable the streamlining of integration and the insertion of technology.

Under Turnkey, the government fences off the communication suite and assumes full responsibility for its design, procurement, land-based systems integration and in some cases, shipboard installation and testing. The shipbuilder provides necessary electrical power, ventilation and cooling services based on established allocations. Through the use of the "phased delivery of GFI," SPAWAR retains the ability to integrate new technology and systems without impacting the shipbuilder's design efforts.

Figure 1 shows the design and production phases of DDG 51 shipbuilding and highlights the Turnkey vs. Non-Turnkey benefits. SPAWAR provides the initial inter-space information and Turnkey Not-to-Exceed en-

Current DDG SCN Turnkey Production Timeline

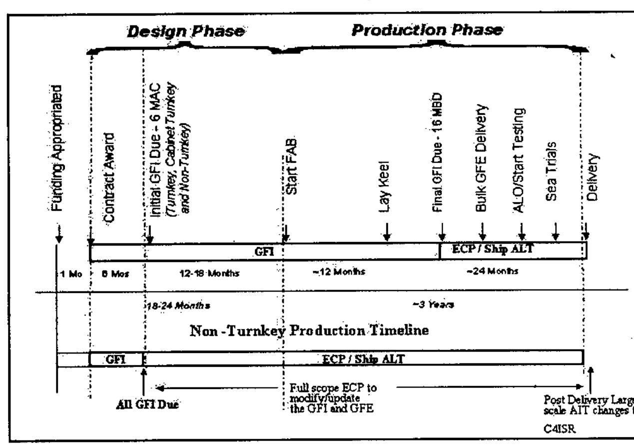

Figure 1

velopes 6 months after the shipbuilding contract is awarded, referred to as "6 MAC". The Initial 6 MAC GFI delivery for the current DDG Shipbuilding Conversion Navy (SCN) Turnkey production timeline consists of all Not-to-Exceed Envelope data such as physical space dimensions, shock excursion details, foundation details, weight, power, heat dissipation, center of gravity, and connector information for the access, equipment and foundation envelopes within the Turnkey space. Additionally, all inter-space information required for systems located external to the Turnkey space is in-

cluded. This primarily is comprised of all data for cabling that exits the Turnkey space and any remote stations/equipment such as CIC, equipment rooms, and Combat Systems spaces.

Over the course of the next 2 and 1/2 to 3 years, the phased delivery of GFI fills in the information for the Turnkey systems and spaces. At 16 Months Before Delivery (MBD), all information is required by the builders to complete design and pre-fabrication work pending delivery of the Government Furnished Equipment (GFE) to the shipyard. Consequently, through the use of Turnkey, technology can be inserted at the latest possible opportunity while at the same time ensuring interoperable *"State-of-the Market"* C4ISR/IW for new construction ships and no additional claims by the builders.

As a comparison to Turnkey, the traditional method of shipbuilding relegated SPAWAR to deliver ***All*** GFI at the 6 MAC stage. At this point, ***All*** rack information, ***All*** system information, ***All*** cabling information (internal and external to radio), ***All*** connector information was provided to the shipyard for design, integration, and installation of C4ISR/IW equipment. The C4ISR/IW design was thus frozen for the next 4 and 1/2 to 5 years until Ship's Custody Transfer. ***Any*** changes to the C4ISR/IW baseline required a full scope Engineering Change Proposal (ECP) to modify/update the GFI and GFE. Any changes not fully documented by the government resulted in a *"delay and disruption"* claim by the builder. Consequently, the Government would wait until after Ship's Custody Transfer to initiate large-scale Alteration Installation Team changes to the C4ISR/IW spaces upon this new warship.

Variations of Turnkey

A precursor to Turnkey was the implementation of Land Based Testing and Integration prior to delivery to the shipbuilder. The first example of this collaborative effort was the CG 47 program. In the mid 1970s, SPAWAR, in conjunction with NAVSEA, developed the practice of land-based integration and testing of communication systems. The primarily goal was to reduce the risk in the integration of the Radio Communications System for the AEGIS CG 47 Class ships. At the same time, the NAVSEA Auxiliary and Special Mission ships project office began a full Turnkey process for the radio communications system on their ships using a SPAWAR field activity. The realization— by removing the risk of late GFE from the process and allowing later insertion of technology, the cost associated with post delivery rip out was reduced and the installation of equipment to meet the ship's operational requirements were satisfied. Since the MILSPEC/MILSTDs in affect at the time prevented speedy Radio Communications System technology upgrades, it did set the stage for the implementation of improved Turnkey approaches later on.

DDG 51. In the early 1990s, SPAWAR collaborated with PEO TSC PMS-400 and conceived the ***"AEGIS Turnkey Approach"*** for the Radio Communications System starting with DDG 73. The DDG 51 Turnkey approach was implemented this space as a part of the fiscal year 1993 DDG 51 AEGIS shipbuilding contracts; Ship's Signal Exploitation Space Turnkey was implemented on DDG 79 in July 1994. This enabled the Radio Communications System baseline to evolve well into the installation and test phase at the land based integration facility instead of freezing it with the release of the request for proposal or RFP. The Turnkey approach has provided the Navy with significant design flexibility by allowing the delivery of GFE and GFI "just in time" to support detailed design, installation, and testing of both spaces onboard the ship. During the collaboration four principles were employed to support this venture.

The four principles that guide the Turnkey approach are:

1. Just In Time Delivery - Turnkey provides system designers an additional 32 months of technology and design flexibility.

By the phased delivery of GFI to the shipyard, SPAWAR gains valuable systems engineering and integration time, which allows for the later insertion of technology. Prior to Turnkey, system configuration was defined up to 5 years ahead of ship's custody transfer.

2. Common Data Format - Common formats and naming conventions are negotiated and agreed upon for each of the deliverable products.

Common data formats eliminate the need for CAD operators and designers to redraw or re-enter entire design products into shipbuilder customized formats. The common formats serve the interest of the government and the shipbuilder.

3. Concurrent Engineering - Originally intended to be a synergistic effort between all design activities to

conduct detailed design and solve engineering problems.

Concurrent Engineering has evolved into daily engineering design sessions between the Government, Shipbuilder, and Lead Yard Service (LYS) engineering staffs. These sessions take place throughout the design process. Through collaboration and negotiation, many design issues are solved thereby, avoiding costly ECPs.

4. Electronic Data Transfer - This step reduces processing time for cable running sheets, the most voluminous deliverable, from 7 weeks to 1 week.

Electronically transferring deliverable products virtually eliminates the need for data entry and the requirement for CAD operators to re-enter or redraw GFI into LYS products that are issued for ship's construction.

Employing these four Turnkey principles provide the program manager and shipbuilder greater Radio Communications System design flexibility and the means for integrating evolutionary changes into new construction ships communications suites, while preserving affordability.

CVN. The CVN and DDG 51 Turnkey approaches are similar, however, SPAWAR and NAVSEA PMS 312 have agreed to a Turnkey approach referred to as ***"Design Budget."*** This approach delays the definition of Radio Communications System/Ships Signal Exploitation Space systems commencing in CVN 76. In this approach, the freedom to continually evolve the system design is as flexible since the finalization of GFI to the shipbuilder is required at 16 MBD. In addition, the system design is frozen prior to delivery of the system to the shipyard for installation by the shipbuilder. Consequently, the final outcome will be the reduction in the number and scope of future ECPs.

LPD 17. SPAWAR and NAVSEA have implemented a government/industry team approach on the LPD 17 shipbuilding program. An Integrated Product & Process Development Team with government program management, contractual, and technical authority are all co-located for the first time at the shipbuilder site. The LPD 17 program's on-site management and functional teams have been involved in establishing operation and support costs reduction goals through total ownership and engineering teams. They have committed to a reduction in operation and support costs through investments in developing alternative systems, components and materials.

SPAWAR/PMS 317, using the lessons learned from the earlier Turnkey approaches, took technology insertion to the next step when they crafted the ***"Full Turnkey"*** process. In this method of Turnkey, SPAWAR has complete responsibility for the land based integration, testing and shipboard installation of the Turnkey Systems (Radio Communications System/Ship's Signal Exploitation Space). This allows both systems to continually evolve throughout the design, integration, test and shipboard installation process. Therefore, this approach should prevent costly changes that are associated with inserting technology late in the ship construction process.

Advantages

Through the use of Turnkey, the DDG 51 program has modified or upgraded 95% of the Radio Communications System/Ships Signal Exploitation Space systems on DDG 73 through DDG 88. These changes were accomplished with a very small number of ECPs. Since the implementation of Turnkey, PMS 400 has realized a Radio Communications System/ Ships Signal Exploitation Space ECP reduction of approximately 77%. Additionally, through the use of the Turnkey process, DDG 51 LYS was able to issue near error free detail design data for the these spaces that avoided costly design changes. It must be emphasized that the Turnkey approach is not a cost savings tool in the ship's design and construction cycle. Turnkey is a **cost avoidance tool** used to implement "Radio Communications System/ Ship's Signal Exploitation Space" changes that do not impact the overall ship's production schedule and delivery dates. The Turnkey approach provides the means for integrating evolutionary technological changes into the C4ISR/IW suites for new construction ships while preserving affordability.

D-30 PROCESS BEGINNING TO OVERLAP THE SCN PROCESS

The Government strives to incorporate C4ISR/IW changes at the most cost-effective point in the SCN construction process. In years past, SCN platforms were not assigned a particular BG until 12-18 months after exiting the SCN window. Within the last year, these ships have fallen into the D-30 (30 months prior to ship's deployment) process since they are now being assigned to BGs well within the SCN timeline. This assignment has produced challenges with regards to fielding the appropriate C4I systems that would be interoperable with the BG

assigned. For example, the USS O'KANE (DDG 77) is assigned to the USS VINSON BG. Although O'KANE is still in the SCN window, the D-30 clock started 15 months ago. In order for O'KANE to exit the SCN window with state-of-the-market C4ISR/IW systems, extensive coordination between NAVSEA, SPAWAR, the shipyards and Advance Installation Teams is a must. Figure 2 shows the overlap of the USS O'KANE's SCN timeline and the USS VINSON BG D-30 schedule. As a result of the merging timelines, SPAWAR and NAVSEA are affecting C4ISR/IW installs at the most

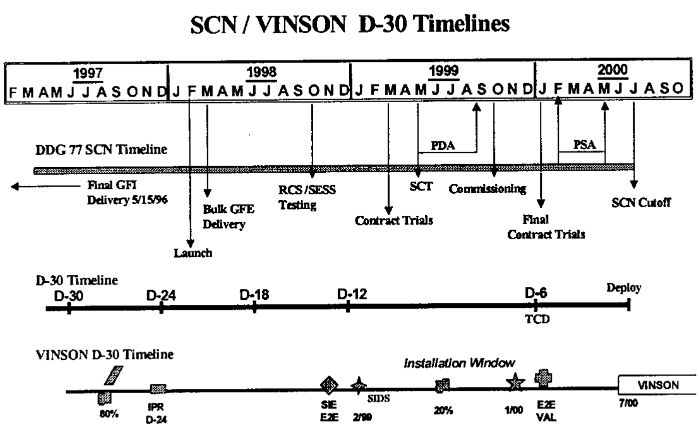

Figure 2

opportune time in the shipbuilding process. Consequently, O'KANE will report to the VINSON Battle Group an *"all up C4ISR/IW round."*

TWENTY-FIRST CENTURY C4ISR/IW INTEGRATION

SPAWAR will play a critical role in preparing and maintaining ships as entities of the overall U.S. Naval Force. Budgetary trends indicate that SPAWAR program management will have to continually improve efficiencies when obligating funding for force readiness, maintenance, technology insertion and research and development. Design activities are expected to continue to do more with fewer resources. The product rollout cycle must be shortened; maintainability and reliability must be sustained and improved. These are daunting tasks which can only be accomplished through smart employment of resources by the greater use of public and private collaborations. One way to accommodate the smart employment of resources is to formulate a systems architecture that will consolidate cabinets and software applications.

Thus far only the Radio Communications System/Ship's Signal Exploitation Space have been discussed as Turnkey spaces. This concept is currently being expanded to cabinets outside of these spaces that include distributive systems such as Integrated Shipboard Networks Systems (ISNS), Navigation System Sensor Interface (NAVSSI), and Global Command and Control Systems – Maritime (GCCS-M). This next generation of Turnkey is called *"Cabinet Turnkey."* Subsequently, the same Turnkey principles apply.

Open Systems Integration Approach

To facilitate the integration of emerging systems, SPAWAR is continually refining the technology insertion process/approaches to C4ISR/IW system integration. An open systems integration approach that controls interfaces rather than defining the equipment slated for integration would enable SPAWAR to defer final selection of systems. SPAWAR total system design teams will define the interfaces by which an equipment group must pair off with its surroundings including integrated HVAC, foundation, cable plants, and power. SPAWAR will then plug the systems selected by platform managers and the Fleet Commanders into this existing backplane via the controlled interfaces. When equipment refreshment becomes necessary, the new systems may be integrated using the existing interfaces. The open systems integration approach would also encourage the reduction of stovepipe equipment selection. Single mission systems that require unique equipment interfaces would be discouraged due to the impact the systems would have on the controlled interfaces. Adhering to interface controls would inherently foster the consolidation of systems and terminals through the use of common data types and transmission media.

Horizontal Integration

Horizontal Integration or HI is the systematic approach to a unified build process, which focuses on a single development and test program that will coordinate all SPAWAR products. This is important because, at the speed in which technology is changing, it becomes very

difficult to ensure interoperability, compatibility and testability all at the same time.

The development process has historically been an "*every program for themselves*" type of approach. In an effort to coordinate programs, SPAWAR is progressing towards an enterprise-wide solution to bridge the evolution of the many products that are provided to its customers. Currently, across the spectrum of SPAWAR products, there are a number of programs such as GCCS-M, NAVSSI, Navy Tactical Command Support System (NTCSS) and Meteorological and Oceanographic System (METOC) that have independently developed or matured at their own pace. Although, each generation or upgrade of those individual systems is more technologically advanced than the last, this does not mean that the overarching capability of a ship or shore station has been increased. By controlling the rate at which the architecture changes across the board, SPAWAR can virtually guarantee that the system as a whole is greater than the sum of the parts.

To accomplish this task, SPAWAR has identified four near term objectives:

- Complete integration of SPAWAR products
- Understand, Claimency-wide, the need to build "functions" not systems
- Institutionalize a 24 month evolutionary update cycle synchronized across all product lines
- Define the attributes of the integrated system

The path to meet these objectives include: total schedule alignment among programs, a single development and test evolution and a single software and hardware baseline with server client consolidation and common Defense Information Infrastructure (DII) Common Operating Environment (COE) Version (4.X). DII COE will serve as the core information exchange structure, and the means to achieve timely accurate information flow. Additionally, Horizontal Integration will incorporate common integration architec ture and security systems architecture. Figure 3 depicts the approach to this process.

Of equal importance is Horizontal Integration's planned implementation. With a unified system, the only practical approach is a unified fielding plan. Leveraging off of "*Cabinet Turnkey*" a common systems design approach to engineering a standard C4ISR/IW back plane can be pursued. This final extension of the Turnkey concept will facilitate the rapid infusion of technology at the latest possible date.

Horizontal Integration
is the next step in SPAWAR
Product Line consolidation effort

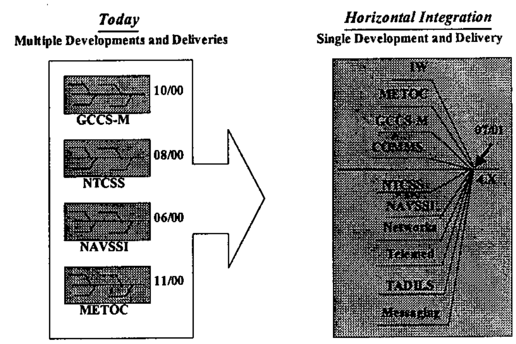

Figure 3

CONCLUSION

The Turnkey process is highly successful at providing the Navy the most technologically advanced Radio Communications System and Ship's Signal Exploitation Space equipment available without incurring a significant increase in shipbuilding costs associated with design changes. However, Turnkey should not be considered a panacea for inserting cutting edge technology. The close collaboration amongst SPAWAR, NAVSEA and industry can provide the most cost-effective methods in which to install C4ISR/IW systems during the shipbuilding process. This approach ensures that the Navy's newest ships are ready to deploy with an interoperable capability. Furthermore, the successful fielding of the rapidly changing C4ISR/IW technology in the 21st Century will pose unique management challenges. SPAWAR, through the use of Turnkey, Horizontal Integration and capitalizing on Acquisition Reform has laid the keel for successfully meeting these challenges.

Mr. Joseph M. Bracewell, BSEE/MSE is the Chief Engineer for Platform Integration Division Oversight at SSC-Charleston Code 33A. He has oversight of all design, acquisition, integration and installation efforts within the division.

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Mr. James E. Burgess is the CVN SCN program manger for CVN 69 and CVN 76, responsible for the oversight of the procurement, design, integration and delivery of the integrated Radio Communications System for both platforms.

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Mr. Mike Cullison is the LPD Turnkey Program Manager at SSC-Charleston for LPD 17 and LPD 18. He is responsible for the oversight of the procurement, design, integration, test and installation of the integrated RCS/SSES for both platforms.

Mr. Glen Hoffman is the LPD-17 Turnkey Test Manager at SSC-Charleston. He is responsible for the oversight of the Test Integration Facility (TIF) testing, Shipboard testing, and Design Integration Testing (DIT).

Mr. Travis Tillman, BSEE is the CVN Design Budget Systems Engineer at SSC-Charleston for CVN 69 and CVN 76. He is responsible for the final review and signature of engineering products and related drawings, as well as interface between SSC-Charleston and the shipbuilder for the RCS for CVN 69 and CVN 76.

Mr. Michael Virnig is the LHD Integration Manager at SSC-Charleston for the LHD-7. He is responsible for the oversight of the integration of SPAWAR C4I equipment associated with the LHD-7.

Mr. Bernard F. Dombrosky serves as a Section Head within the Combat and Communications Systems Team at Naval Air Warfare Center Aircraft Division (4.5.8.3) and is responsible for all engineering and integration efforts for the DDG 51 Class RCS.

Mr. Timothy P. Hickey is the Combat and Communication Systems Team lead engineer for the design of the RCS and the Ships Signal Exploitation Space (SSES) for the DDG 51 Class ships at Naval Air Warfare Center Aircraft Division (4.5.8.3).